State of CERES

Norman G. Loeb
NASA Langley Research Center, Hampton, VA

CERES Science Team Meeting, September 1-3, 2015
University of Washington, Seattle, WA

CERES Meeting & Workshop Objectives

Major Objectives for the Meeting:

1. Review status of CERES Instruments and Data Products:
- CERES Project Status
- CERES Terra, Aqua and SNPP SW/LW/TOTAL Channel Calibration Update
- CERES FM6 and RBI Update
- CERES Cloud Algorithm & Validation Status: MODIS, VIIRS, GEOs
- CERES TOA Flux & Angular Distribution Model Update: FM1-FM5
- SOFA, SARB and TISA Working Group Reports
- FLASHFLUX Update
- Plans for Next Version of EBAF-TOA and EBAF-SFC
- Data Management Team Update: Terra/Aqua/SNPP
- CERES Education Outreach

2. Invited Presentations Session: Each presentation is 45 min.

3. Contributed Science Reports. Each report is 20 min including time for questions.

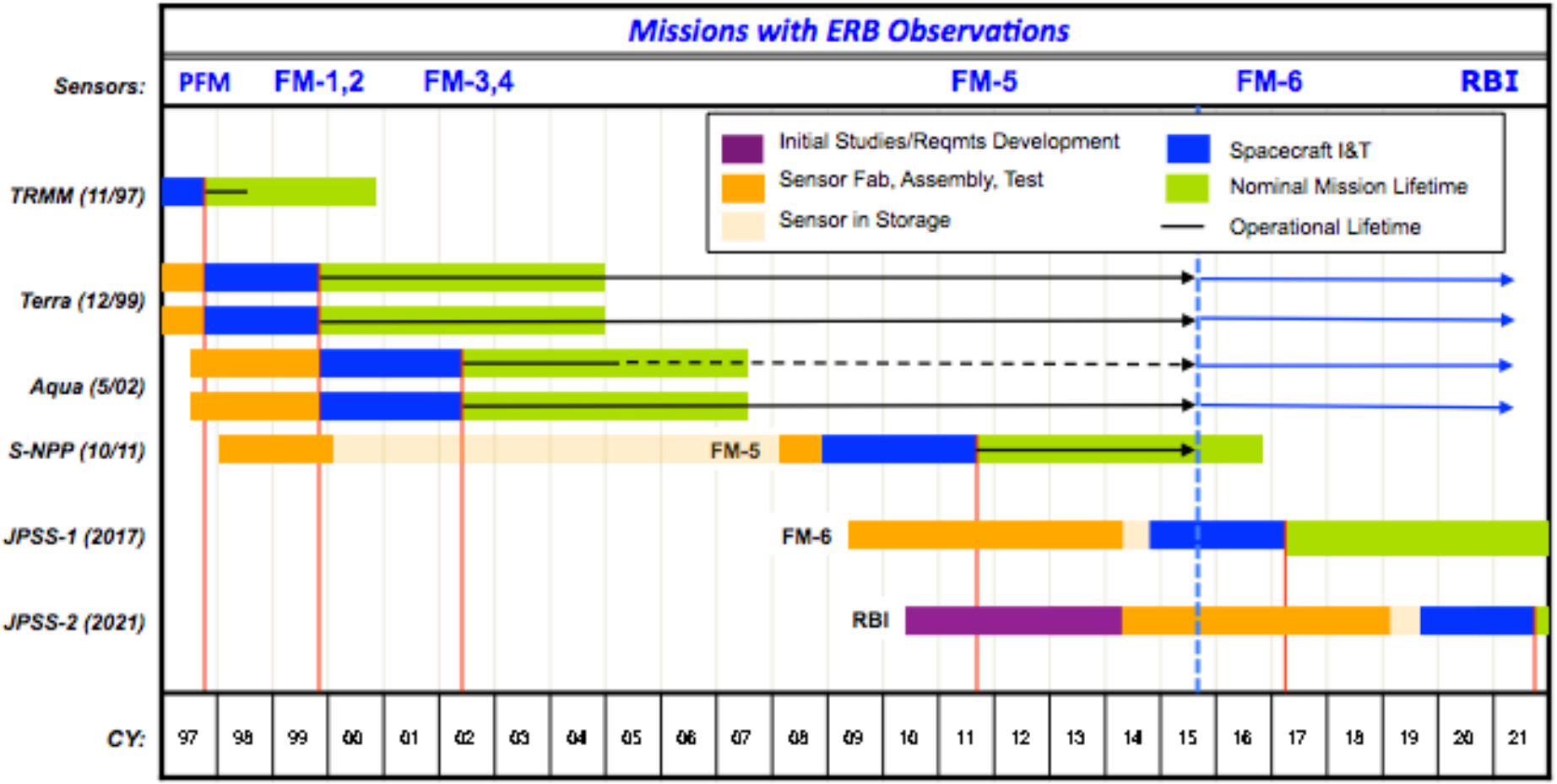
CERES Team Leads

- Principal Investigator: Norman Loeb
- Project Scientist: Kory Priestley

CERES Working Groups:

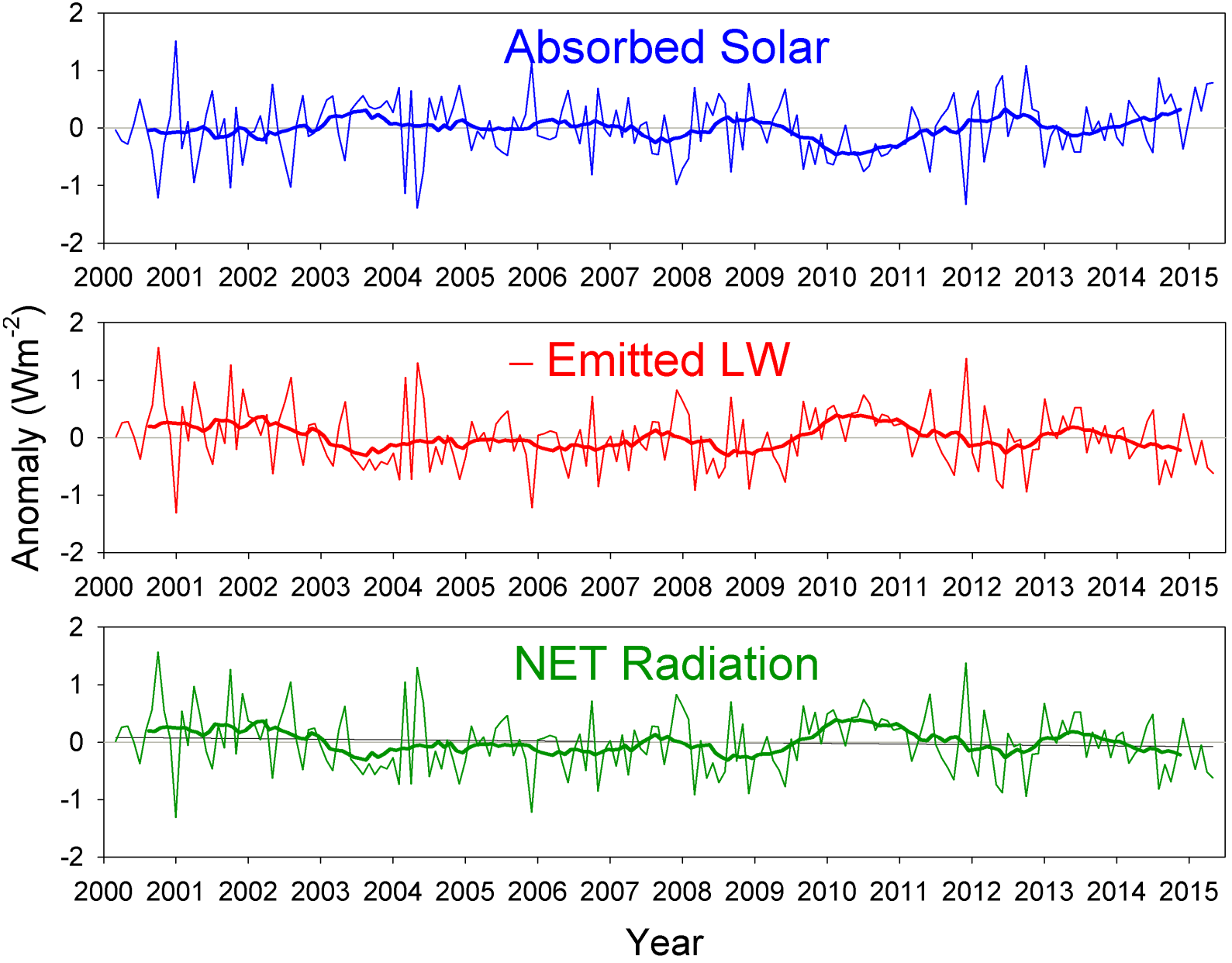
- Instrument: Kory Priestley
- ERBElike: Takmeng Wong
- Clouds: Pat Minnis (Lead); Bill Smith Jr., (Deputy)
- Inversion: Wenying Su
- SOFA: David Kratz
- SARB: Seiji Kato
- TISA: David Doelling
- FLASHFlux: Paul Stackhouse & David Kratz
- Data Management: Jonathan Gleason
- ASDC: John Kusterer

CERES & RBI Flight Schedules

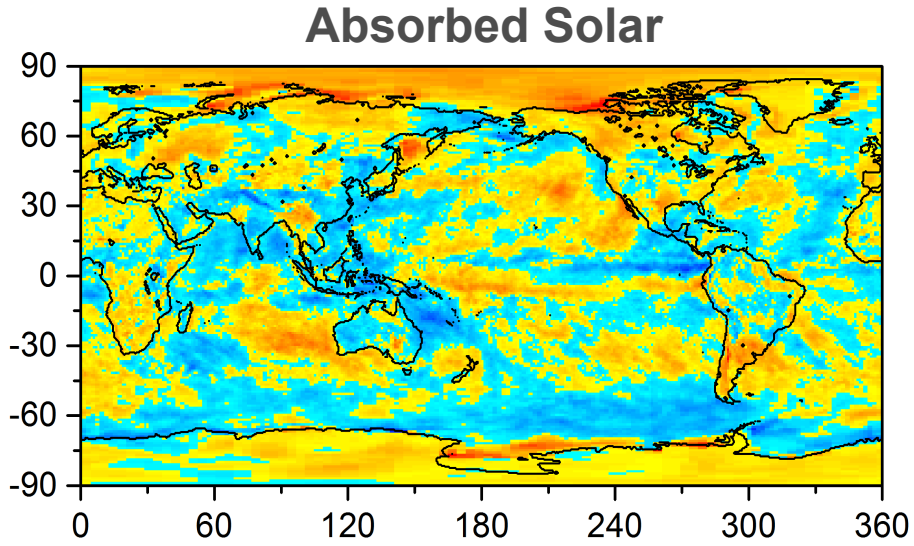


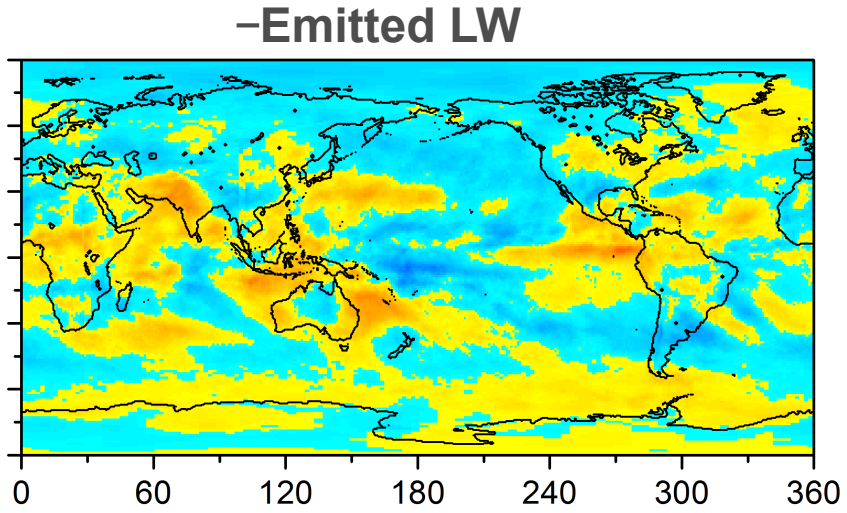
- Currently, 5 CERES instruments fly on 3 satellites: Terra (L1999), Aqua (L2002) and SNPP(L2011).
- CERES FM6 will fly on JPSS-1 in FY17 (2nd Qtr). The CERES follow-on instrument (Radiation Budget Instrument, or RBI) will fly on JPSS-2 in FY21 (4th Qtr).

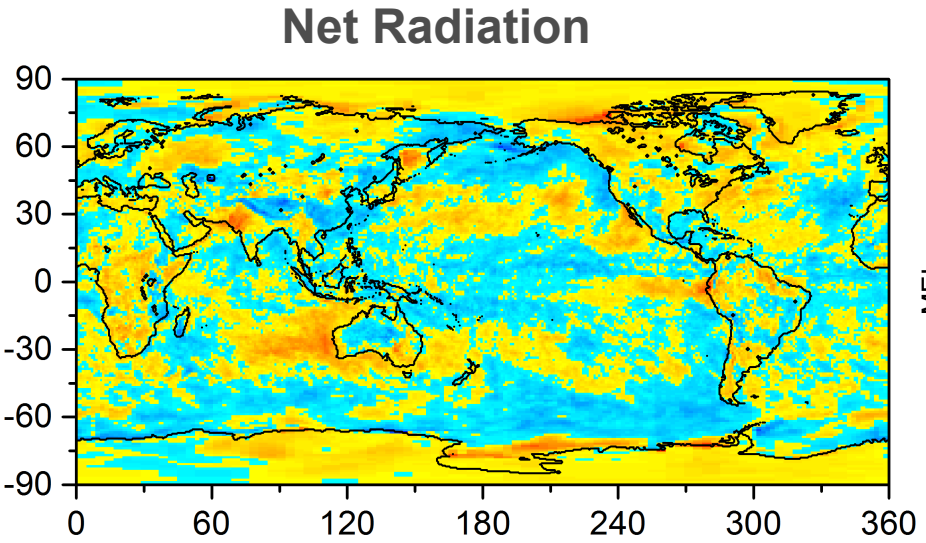
Global TOA All-Sky Radiation Anomalies
(CERES_EBAF_Ed2.8; 03/2000 – 05/2015)

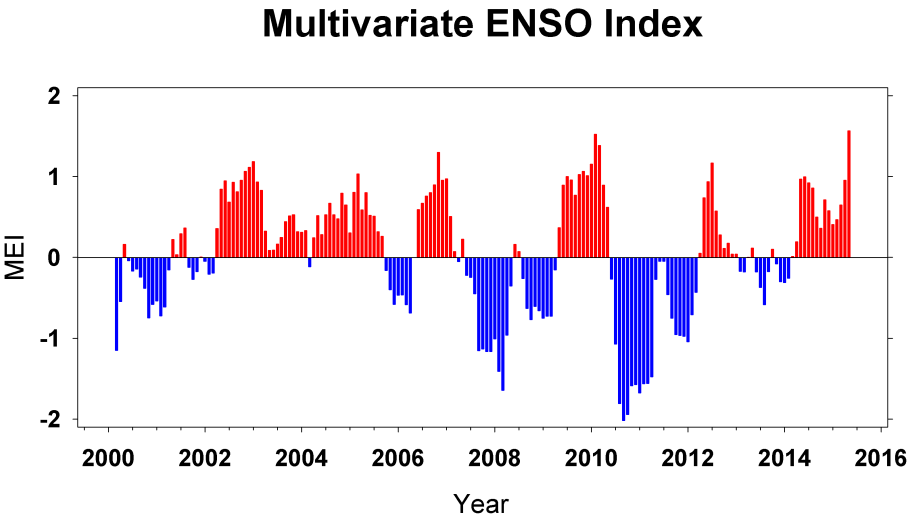


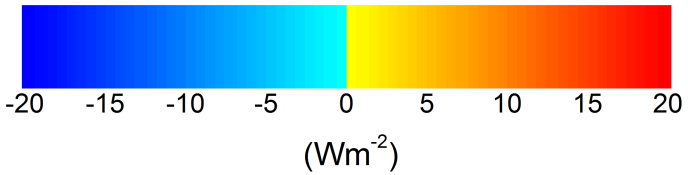
TOA Radiation Changes (March 2000 – May 2015)











CERES Reviews - 2015

1) Earth Radiation Budget Science PPBE Review (April 15)

2) Terra and Aqua Senior Reviews
   - Proposal submitted in late March
   - Panel review April 29, 2015

3) Earth Radiation Budget Science Team Review (May 4)

4) NASA LaRC Science Directorate Peer Review (October 13)

Senior Review Results

Table 1. Mission-specific findings

Mission	Science Scores			Numerical Science Score	Adjectival Summary Science Score	Utility Score	Technical Risk	Cost Risk	Conclusion	
	Merit	Relevance	Product Quality						FY16-17	FY18-19
Aqua	5.0	5.0	5.0	5.0	Excellent	Very High	Low	Low	Continue	Continue
Aquarius	5.0	5.0	4.0	4.7	Excellent	High	Low	Low	Continue	Continue
Aura	5.0	5.0	5.0	5.0	Excellent	High	Medium Low	Low	Continue	Continue
CALIPSO	5.0	5.0	5.0	5.0	Excellent	High	Medium-Low	Medium-Low	Continue	Continue
CloudSat	5.0	5.0	5.0	5.0	Excellent	High	Medium-Low	Low	Continue	Continue
EO-1	2.8	2.9	3.0	2.9	Good	Some	Medium	Low	Terminate & Close-out	[closed]
GRACE	5.0	5.0	5.0	5.0	Excellent	High	Medium-High	Medium-Low	Continue	Continue
OSTM	5.0	5.0	5.0	5.0	Excellent	High	Medium-Low	Medium-Low	Continue	Continue
SORCE	4.0	5.0	4.0	4.3	Very Good	High	Medium-High	Low	Continue	Continue/Augment
Terra	5.0	5.0	5.0	5.0	Excellent	Very High	Low	Medium-Low	Continue	Continue

* All science scores are on a 1-5 scale with 1 being the lowest ranking of "poor" and 5 being the highest ranking of "excellent". Additional commentary or conditions on the Panel's scores and/or conclusions are noted in the mission-specific findings summary below.

Proposed Waiver to Terra Constellation Exit Plan

- **Original plan**: In order for Terra to exit the morning constellation safely, it must first lower its orbit to 19 km below the constellation.
  - An orbit-lowering maneuver would be performed in 2017 and the spacecraft would then naturally slowly drift down to 10:15 am MLT by 2022.
  - Terra satellite reentry would occur in 2057.
- Upon further analysis, it was determined that this safe exit approach was overly conservative: safe exit only needs to be approximately 4 km below the constellation.

Proposed Waiver to Terra Constellation Exit Plan

- **Proposed Plan**: Terra would like to pursue exiting the constellation according to the new constellation exit requirement of 4 km instead of 19 km.

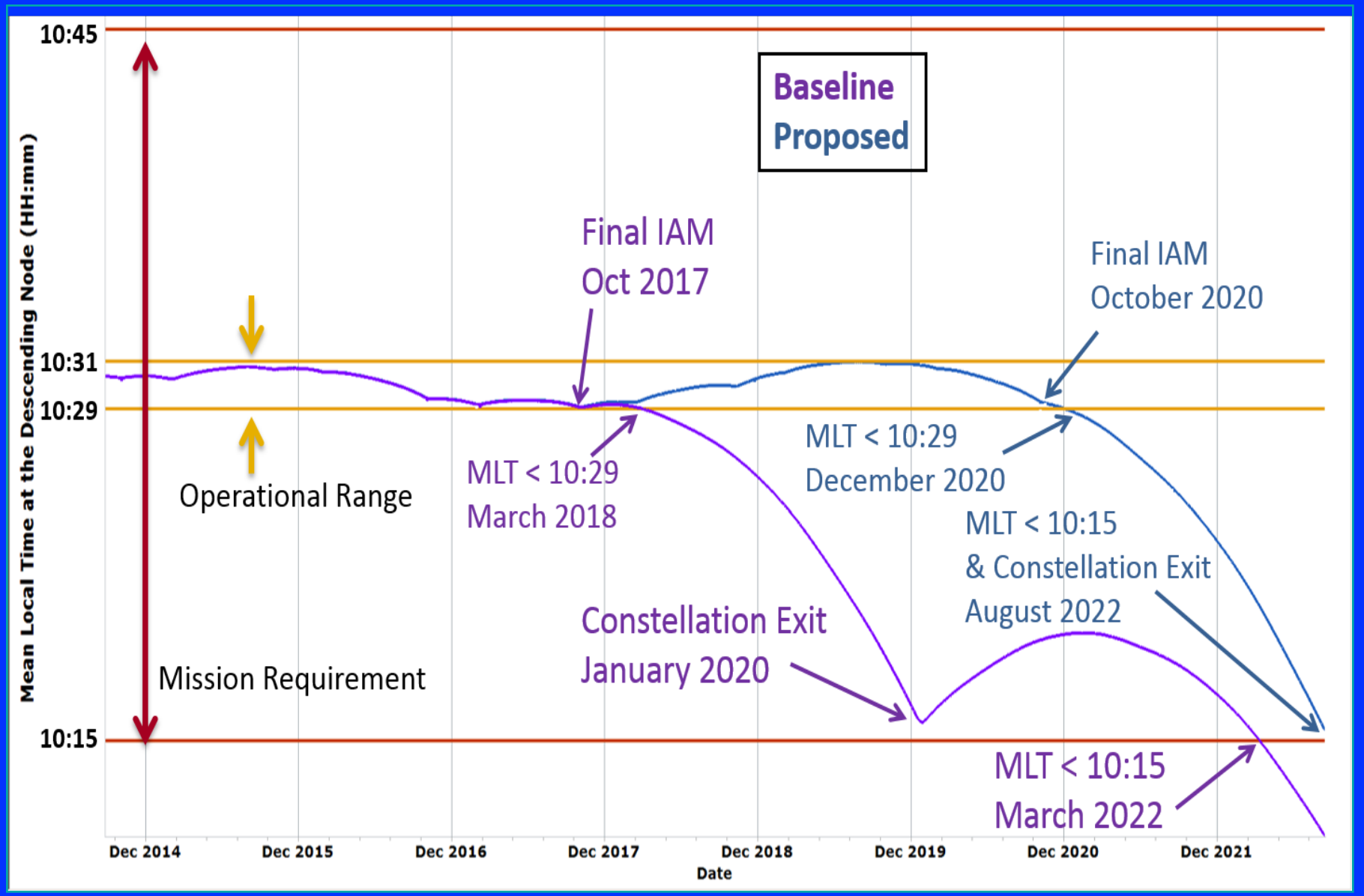
  ⟹ Would require fewer maneuvers to exit the constellation and therefore less propellant would be needed in reserve for constellation exit.

  ⟹ Would enable Terra to maintain the 705 km altitude and the tight 10:30 MLT for nearly three additional years (it's been within 1 min since early in the mission).

  ⟹ Terra satellite reentry would occur in 2077.

NOTE: In either scenario, Terra will be able to collect science data through 2025 when the MLT drifts past 9:00 am.

Terra MLT following baseline constellation exit vs proposed exit



Issues/Concerns with Proposed Waiver

Additional Debris Risk: If lowered 4 km below the constellation, Terra satellite would remain in orbit for 20 more years (2077 vs 2057) before reentry.

⟹ Increases chance that Terra could be hit by a piece of debris before reentry and thus create more debris in low Earth orbit altitude regimes.

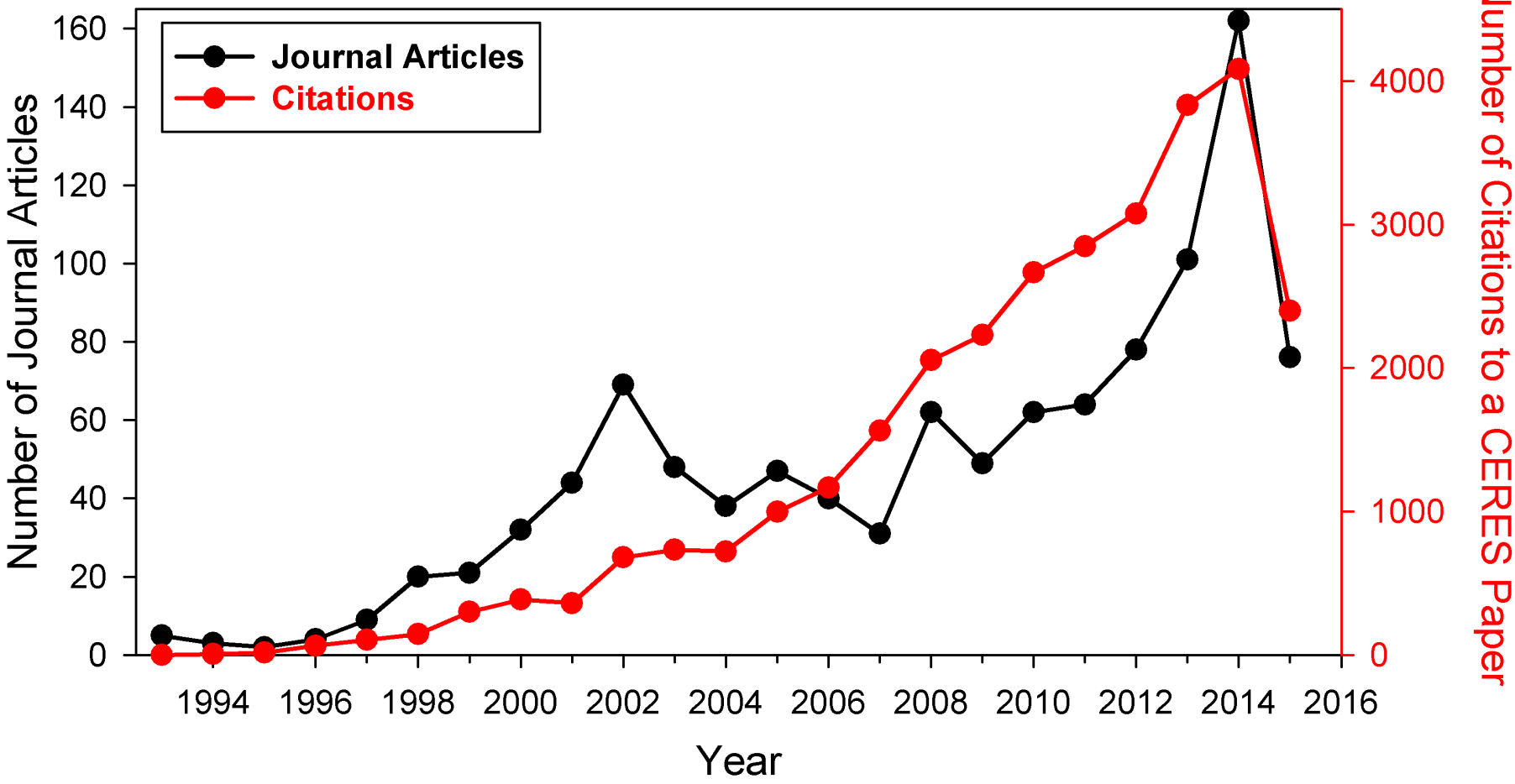
- However, the increase in collision risk to a typical member of the 705 km Earth Science Constellation is minimal.
- To get an independent assessment, ESMO asked the Aerospace Corporation to perform a constellation risk analysis between the two exit strategies:

Orbit	Risk of Terra Breakup
4 km (701 km)	1 in 100,000
19 km (686 km)	1 in 103,100
Current (705 km)	1 in 108,700

Senior Review Panel Recommendation

- If the waiver is denied, Terra would certainly continue to collect high quality data of sufficient value to the science community to warrant extension.
- Orbital change would compromise continuity of the stable long term climate record at some level, but additional information is necessary to fully assess the significance of this degradation.
- A sensor-specific or even data product-specific table of risks to data continuity resulting from waiver non-approval is needed.
- Panel suggests that NASA convene a workshop of data users to discuss and evaluate the trade-offs associated with the waiver decision.

CERES Journal Publication and Citation Counts
(For Papers Between 1993-2015; Updated August 17, 2015)



- Total number of peer-reviewed journal articles: 1,067
- Total number of citations to CERES papers : 30,436

Compiled by Anne Wilber & Dave Kratz

Number of Unique Users by CERES Data Product (Updated August 25, 2015)

Level	Product	2010	2011	2012	2013	2014	2015
1b	BDS	11	9	14	8	7	3
2	SSF	84	77	138	201	211	178
	FLASH_SSF	25	8	15	12	24	53
	C3M	31	32	33	19	6	10
	ES8	22	20	18	21	5	5
	SSF-MISR	9	4	2	5	4	0
3 & 3b	EBAF-TOA	72	160	346	480	567	412
	EBAF-Surface			147	285	364	308
	SYN1deg	41	126	179	315	355	317
	SSF1deg-lite	46	106	93	139	157	103
	ISCCP-D2like	17	12	37	53	38	32
	ES4	59	36	11	17	6	3
	ES9	21	12	5	9	3	3
	FLASH_TISA	17	18	20	11	3	3
	SFC	31	20	14	6	2	0

CERES Terra and Aqua Edition 4 – Status

- Instrument gains and SRFs: Delivered
  - Improvement to Aqua SW part of TOT SRF.
- CERES Clouds code: Delivered.
  - Increased cloud fraction (more consistent with CALIPSO).
  - Decreased cloud optical depth (more thin clouds).
  - Significant improvements to polar cloud mask.
- Inversion (ADMs and SOFA) code: Delivered.
  - 2nd generation CERES ADMs; Improved parameterized surface fluxes.
- SARB and TISA code: Delivered.
  - Use of 5-channel 1-hourly GEO cloud retrievals.
  - Consistent reanalysis and MODIS calibration throughout.
  - SYN1deg to be released 1-hourly, 3-hourly, daily and monthly.
  - Consistent non-GEO and GEO TISA products (all GMT).
  - Improved to Fu-Liou RT code and ancillary inputs (e.g., Ed4 clouds+overlap, surface albedo, MATCH aerosols).

CERES Terra and Aqua Edition 4 Status

Current Processing:

- BDS processed through December 2014
- SSF processed through November 30, 2012
- SSF1deg processed January 2005 – November 2009
- SYN1deg processed January 2008 – June 2008

Anticipated Level 3 Release Dates

(After 2 years have been processed):

- SSF1deg-Day/Month released – August 26th, 2015
- SYN1deg anticipated release – October 14th, 2015
- CldTypHist anticipated release – March 2016

EBAF Ed4.0

(After 5 years have been processed):

- Early CY 2016

CERES FM5 SNPP

- CERES FM5 time-varying gains and beginning of mission SRFs to be used in SSF Edition 1.
- Receiving Collection 1.1 calibrated VIIRS radiances from GSFC Land PEATE (Xiong).
- CERES Edition 1 Clouds: Delivered.
- SSF Edition1 uses Edition 4 Aqua ADMs.
- Anticipate “MODIS-Like” VIIRS aerosols from Land PEATE (POCs: Rob Levy & Christina Hsu). Consider including in Edition 2.
- Ed1 SSF production was halted in spring 2015 due to a code error that excluded footprints in each hourly file.
- Code fix has since been redelivered and production was restarted in August.
- Current Status: Ed1 SSF production started August 2015.

Future Earth Radiation Budget Missions

- Responsibility for sustained climate measurements transferred from NOAA to NASA.
- CERES FM6 to launch on JPSS-1 in Nov 2016.
  - CERES team to produce Earth Radiation Budget Climate Data Records using CERES FM6, closely following FM5/SNPP approach.
- Radiation Budget Instrument (RBI) Status:
  - Draft RFP released in April, 2013
  - Industry-Day April 30, 2013
  - Official RFP release: June 14, 2013
  - Award: Spring 2014
  - RBI delivery date: Spring 2019.
  - Launch on JPSS-2: November 2021.

COVE

- DOE has turned Ches Light over to GSA for excess; will take several more months to complete the process.
- Meanwhile, DOE is letting us run autonomously until a new owner is found. BSRN suite is still operational.
- DOE is also allowing us to take one more trip this year, so that we can refresh instruments that are near the end of their calibration.
- Owners of Frying Pan and Diamond Shoal lights want to purchase Ches Light.
- Both owners would prefer that we stay on the platform and pay them rent.

New CERES Webpage Design

- Includes a new search engine for CERES publications and science team meeting presentations.
- http://ceres.larc.nasa.gov/index.php

Upcoming Conferences & Meetings of Interest

Intl Conference on the Water and Energy cycles in the Tropics
- November 17-19, 2015, Paris, France

American Geophysical Union
- December 14-18, 2015, San Francisco, CA

AMS Annual Meeting
- Jan 10–Jan 14, 2016, New Orleans, LA

International Radiation Symposium 2016
- April 17-23, 2016, Auckland, New Zealand (Oct 1 abstract deadline)

Spring 2016 CERES Science Team Meeting
- Date TBD, NASA Langley Research Center, Hampton, VA

Other CERES Related News

- Terra lunar deep space calibration maneuver. Request awaiting approval at NASA HQ.
- CERES/ScaRaB PAPS campaign (March 22 – May 31).
  - Idea is to repeat campaign conducted two years earlier to assess any instrument changes between the two campaigns.

Other News

- MERRA-2 access at the GED DISC available starting tomorrow (Sept 2).
- SORCE operating in “hybrid” mode (collecting solar measurements during orbit day and then going into safe-hold during eclipse periods to conserve battery power).
- TSIS is planned for a launch on ISS in the 2017-2018 timeframe.
- CALIPSO – Functioning nominally
- CloudSat – Returned to the A-Train. Nominal Daylight Only Operations (DO-Op) continue.
- Deep Space Climate Observatory (DSCOVR)
  - Launched Feb 11, 2015.
  - Reached its orbit position between Earth and sun at Lagrange point 1.5 million km from Earth on June 8.
  - First image of entire sunlit side of Earth on July 20.
  - EPIC and NISTAR are the Earth-viewing instruments.
  - LaRC received grant to generate NISTAR fluxes (Minnis/Su Co-Pis).

Earth Polychromatic Imaging Camera (EPIC) on DSCOVR Satellite
(3:50 p.m. - 8:45 p.m. EDT, July 16, 2015)

Other News

- Cloud-Aerosol Transport System (CATS) on ISS
  - Launched Jan 10 and installed on the ISS Jan 22. First science data received in February.
  - Backscatter & depol. lidar at 355, 532 and 1064 nm; HSRL at 532 nm.
  - 51 deg inclined orbit of ISS => diurnal sampling of clouds & aerosols.
  - LaRC CALIPSO team to develop CALIPSO-Like data product.
  - CATS continues to operate nominally.

- CLARREO Pathfinder mission on ISS in FY2019 in President's budget.

End